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Older adults, interface experience and cognitive decline

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ABSTRACT

This paper describes an experiment undertaken to investigate intuitive interaction, particularly in older adults. Previous work has shown that intuitive interaction relies on past experience, and has also suggested that older people demonstrate less intuitive uses and slower times when completing set tasks with various devices. Similarly, this experiment showed that past experience with relevant products allowed people to use the interfaces of two different microwaves more quickly and intuitively. It also revealed that certain aspects of cognitive decline related to aging, such as central executive function, have more impact on time, correct uses and intuitive uses than chronological age. Implications of these results are discussed.

Author Keywords

Intuitive Interaction, intuitive use, prior experience, inclusive design, older people, ageing.

ACM Classification Keywords

H5.2 [**User Interfaces**]: User Centered Design.

1. INTRODUCTION

Intuitive interaction with complex product interfaces is based on past experience, and is generally fast and non conscious (Blackler and Hurtienne, 2007; Blackler, 2008b). Our previous work has shown that prior experience is the vital component of intuitive interaction and that including familiar features in interfaces (cameras and remote controls) allows people to use them more quickly and intuitively (Blackler, 2008b; Blackler et al., 2010). Others have reported similar findings, with prior experience allowing people to use cars, cameras and microwaves more quickly and with less errors (Langdon et al., 2007; Lewis et al., 2008), and intuitive interaction has become strongly linked with prior experience in the literature (Mohs et al., 2006; Hurtienne and Blessing, 2007; Hurtienne and Israel, 2007; Blackler, 2008b; Marsh and Setchi, 2008; O'Brien et al., 2008a; O'Brien et al., 2008b; Blackler et al., 2010).

However, our work has also suggested that older people use complex products (cameras and universal remote controls) both more slowly and less intuitively, even when they report equivalent levels of prior experience (Blackler, 2008b). Other researchers have also found that older people use interfaces more slowly and with more errors (Langdon et al., 2007; Lewis et al., 2008).

Older people encounter a broad range of technologies. Many of them are keen to use new technologies (Rabbitt and Carmichael, 1994; Fisk et al., 2004), but find complex devices difficult to use. Our current research is aimed at finding ways to design interfaces that will allow older people to use them more intuitively. Technology is very dynamic, and it is likely that there will always be a disparity between the experience of older adults and the new devices of the day (Fisk et al., 2004), which makes this research relevant and, indeed, essential.

2. EXPERIMENT DESIGN

This paper reports results from an experiment with prototype microwave interfaces. This experiment was designed to investigate the differences in task performance times, intuitive uses, and correct uses between three different age groups. This was a matched subjects 2x3 experiment design. Independent variables were age group and microwave interface and dependant variables were time to complete tasks, percentage of correct uses, and percentage of intuitive correct uses. The focus of this paper is the differences between age groups, and results of the interface comparison will be published at a later date. The process of prototyping the interfaces for testing is discussed elsewhere (Blackler, 2008a).

2.1 Participants

Participants were recruited from university staff and students, employees of local businesses, and a club for retirees. There were 36 participants, 18 in each microwave group and 12 in each age group. Age groups were Younger (Age range 20-39, Mean 29.08, SD 5.87), Middle (Age range 40-56, Mean 47.67, SD 3.31) and Older (Age range 57+, Mean 63.17, SD 5.37). Within each group, participants were matched for level of education, gender and Technology Familiarity (TF).

2.2 Apparatus and Measures

A TF questionnaire was used as part of the recruitment process, and the resulting TF score was used in the process of matching the participants in each group. TF is a variable used in our previous research as a measure of prior experience. It is measured through a questionnaire, in which participants provide details of their experience with relevant products that have similar features to those they will encounter during the experiment. More frequent and more extensive use of the products in the questionnaire produces a higher TF score (Blackler et al., 2004; Blackler, 2008b; Blackler et al., 2010).

The two microwave interfaces were both prototyped. One was an existing commercial microwave interface and the other a new design intended to be more intuitive. Our touchscreen prototypes (Fig. 1) were relatively high fidelity, although there were some differences between them and a real microwave, which created some challenges. Strategies were implemented to overcome these (Blackler, 2008a). For example, a training interface and 3D cardboard mock-ups were used to support participants in understanding and interacting with a partly 3D interface presented on a 2D screen.

Fig. 1. Microwave prototype in use on touchscreen

Baddeley's model of Working Memory, which has dominated the field for more than 30 years, includes the "central executive" (CE) and three "slave systems" – the visuospatial sketchpad, the phonological loop and the episodic buffer (Baddeley, 1996; Morrison, 2005). The central executive performs cognitive tasks like reasoning, problem solving and language (Morrison, 2005). The executive is able to encode and retrieve information both from the slave systems and from temporarily activated components of Long Term Memory (LTM) (Baddeley, 1996). It is involved in both deductive and analogical reasoning, and inhibition of irrelevant information (Morrison, 2005). The central executive is also responsible for controlling attention, and coordination of the slave-systems. After 30 years of research and some tweaking of the model, the central executive is now seen as a system which regulates and controls information in working memory (Baddeley, 2000).

Based on Baddeley's model, we devised a battery of computer-based tests to measure a range of Working Memory functions (relating to both slave systems and CE). Phonological Loop capacity was measured via a digit span task using a staircase procedure. Visuo-spatial Sketchpad capacity was measured using a Corsi Block task controlled by a staircase procedure.

Sustained attention was assessed using a vigilance task where participants viewed pairs of shapes displayed for 1 second each and had to respond by touching a button on the touchscreen whenever the pair consisted of identical shapes. The capacity of the Central Executive to manipulate phonological and spatial information was measured using two transform tasks. In the phonological transform task, participants had to retain a four digit string in memory while moving each digit forward by a specified number of places. Similarly, in the visual transform task, participants were required to retain in memory a set of four locations spaced around a circle whilst moving each location forward by a specified number of locations around the circle.

Participants' hand-eye coordination was also assessed in a task where a sequence of locations in a 10x10 grid on the screen were highlighted and they had to touch each highlighted location as rapidly as possible. In all but the two span tasks, both response speed (reaction time) and accuracy were recorded. These tests were all undertaken using the touchscreen. Raw values of these measures, rather than age adjusted values, were used.

Time to complete tasks is an important variable for measuring intuitive interaction, as intuitive interaction is assumed to be rapid since it is generally correct, and also because it is a fast, non-conscious process that does not require reasoning (Blackler and Hurtienne, 2007). Correctness and intuitiveness of feature uses were determined by a process we have used successfully over the past several years. This involves coding each feature use from the audiovisual data of participants performing set tasks. A set of heuristics based on the literature is used to determine which feature uses are intuitive. Intuitive uses show less evidence of conscious reasoning in the verbal protocol, are typically fast, have low latency, participants are fairly confident they are doing the right thing, and they may mention that they have seen or used the feature before. The majority of intuitive uses are correct, but correct uses may not be intuitive – for example participants may spend time logically reasoning what to do (Blackler et al., 2004; Blackler, 2008b).

2.3 Procedure

All experiments took place in an air-conditioned laboratory. Participants were first welcomed to the room and were given an information package and consent form. Then all the equipment to be used and the tasks to be performed were explained clearly using a pre-determined script. The participants were asked to complete three tasks using one of the touchscreen microwave prototypes. They delivered concurrent (think aloud) protocol while they performed the tasks. Finally, they completed the battery of Working Memory tests. The tasks were:

The time is 12.30 and you have a pre-prepared 500g frozen burger which you want to eat for lunch. You are going to prepare it using the microwave.

- Put the burger into the microwave. Defrost it.
- The burger needs to "stand" for 2 minutes and 30 seconds after defrosting. Set the kitchen timer so that the microwave times this standing time (without cooking).
- Now you are ready to cook your meal. Cook at medium power for 3 minutes and 30 seconds. Then remove the burger to eat it.

3. RESULTS

Results of a multiple regression analysis (Table 1) showed that time to complete tasks was most impacted by reaction time and accuracy on the phonological transform test. The next most significant variable for time on tasks was TF (Fig. 2), followed by hits on the sustained attention test. The percentage of intuitive correct uses was impacted most by sustained attention accuracy, and also by TF. Percentage of correct uses was most related to phonological transform accuracy, followed by TF.

Independent variables	Unstandardised Coefficients		Standardised Coefficients	r^2	t	Sig.
	B	Std. Error	Beta			
Dependant variable: Time to complete tasks						
(Constant)	935.776	223.235			4.192	.000
Phonological transform reaction time	.016	.003	.550	.559	4.838	.000
Phonological transform accuracy	-10.354	5.349	-.203	.674	-1.935	.065
TF	-8.715	3.398	-.292	.731	-2.565	.017
Attention hit	-10.990	4.912	-.233	.777	-2.237	.035
Dependant variable: Percentage intuitive correct uses						
(Constant)	-44.277	16.552			-2.675	.013
Attention accuracy	13.805	3.470	.513	.556	3.978	.000
TF	1.237	.311	.513	.725	3.973	.001
Dependant variable: Percentage correct uses						
(Constant)	-46.648	22.242			-2.097	.046
Phonological transform accuracy	2.543	.683	.521	.377	3.722	.001
TF	1.115	.399	.390	.521	2.790	.010

Table 1. Results of multiple regression analysis

4. DISCUSSION

As we have found previously (Blackler, 2008b), this experiment has shown that TF is a vital factor in fast, correct and intuitive use of an interface. Age itself does not appear as one of the significant variables in the regression analysis, but the variables that had the most impact all require use of the central executive (phonological transform and attention). There is a growing body of research evidence pointing to age-related deficits in central executive functioning. In past experiments, some tasks could have been affected by age-related processing speed decline, but newer research has controlled for this and still found an effect between age and CE functioning (Fisk and Sharp, 2004).

Older adults vary considerably in their level of cognitive ability, but many demonstrate some decline in CE function. This decline impairs strategic, controlled processing at encoding and retrieval, thus affecting memory. Executive difficulties in aging are not limited to memory tasks but may be central to why older adults experience memory difficulties. Suggested reasons for this decline include multiple small infarcts in the brain, as white matter integrity is correlated with executive function. In addition, the neuro-chemical dopamine declines with age, and it is also associated with performance of executive tasks (Buckner, 2004).

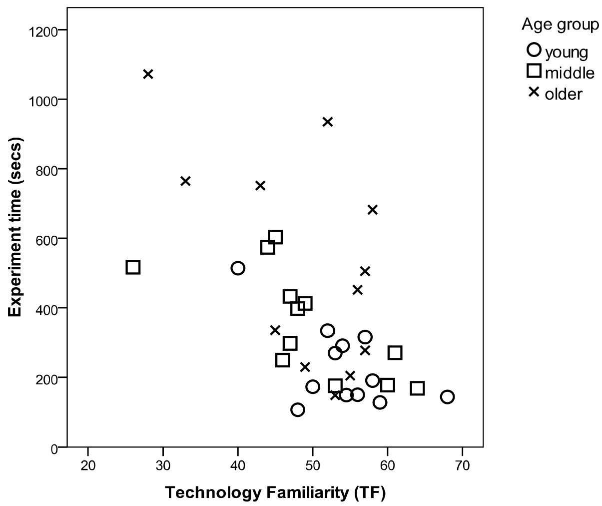

Fig. 2. Time to complete tasks by TF and age group

However, factors such as education level and IQ may mitigate cognitive decline. In imaging studies, older adults show increased recruitment of atypical brain pathways, which may be a compensatory response to aging. Increased recruitment may enable high performing older adults to maintain a high level of performance despite the presence of detrimental physiological changes (Buckner, 2004). This may explain why our results showed that central executive function is more important in speed, accuracy and intuitiveness of using the interfaces than age per se. Older people form an extremely diverse group and Technology Familiarity and specific cognitive abilities (such as CE function) are more relevant than chronological age.

5. CONCLUSION

This experiment has shown that CE function and TF both have an important effect on time to complete tasks, correctness and intuitiveness of feature uses. This concurs with our previous findings that TF has an effect on all three of these variables (Blackler, 2008b; Blackler et al., 2010), and with other researchers (Langdon et al., 2007; Lewis et al., 2008), who found that both cognitive capabilities related to ageing and prior experience were influential on time to complete tasks and errors made.

However, there is currently no firm understanding of the experience of older people with various technologies, and how that experience relates to their use of new things. We are developing methods by which their experience can be ascertained by and for designers (Lawry et al., 2010), and applied to interfaces (Gudur et al., 2009).

This research suggests that a complex mix of abilities and experience, rather than simple chronological age, affect how older people use new interfaces. Designing interfaces suitable for older people will therefore involve balancing these aspects. Our research is continuing in order to find the most appropriate ways in which this can be done.

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